



Classroom-based programs of retrieval practice reduce middle school and high school students' test anxiety[☆]



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ABSTRACT

When retrieval practice is applied in classroom settings, do K-12 students experience changes in test anxiety? To answer this question frequently asked by educators, we surveyed 1408 middle school and high school students about their study strategy preferences and their reactions to a classroom-based program of retrieval practice. For classes in which retrieval practice occurred, 92% of students reported that retrieval practice helped them learn and 72% reported that retrieval practice made them *less* nervous for unit tests and exams. This study is the first to examine the relationship between retrieval practice and classroom test anxiety, and self-reported study strategy use in pre-college students. In light of our results, we encourage K-12 teachers to use retrieval practice in their classrooms to reduce test anxiety and improve learning.

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1. Introduction

Several recent publications have reported surveys of study strategies typically used by college students (Hartwig & Dunlosky, 2012; Karpicke, Butler, & Roediger, 2009; Kornell & Bjork, 2007), as well as recommendations for effective study strategy use (e.g., Dunlosky, Rawson, Marsh, Nathan, & Willingham, 2013). These surveys reveal that college students rarely use effective study strategies (e.g., retrieval practice and distributed learning); instead, relatively ineffective study strategies such as re-reading, highlighting, or underlining are more commonly used. Even when college students are aware of or experience effective study strategies

during an experiment, they routinely fail to implement these strategies during learning, and they continue to report a preference for ineffective strategies such as re-reading (Agarwal, Karpicke, Kang, Roediger, & McDermott, 2008; Karpicke, 2009; McCabe, 2011; Rawson, Dunlosky, & Sciarrelli, 2013; Susser & McCabe, 2013).

While college students use rather ineffective strategies and fail to adopt effective strategies, it is surprising that additional years of experience in competitive post-graduate programs with increasingly difficult content does not appear to shift students' study habits: medical students and surgical residents have also reported using relatively ineffective strategies (Boehler et al., 2001), and only 3% of surgical residents reported being "completely satisfied" with their current study routine (Yeh et al., 2012).

Considering this troubling state of affairs regarding students' use of ineffective study strategies, researchers have called for the implementation of study strategy training programs for students (e.g., Wissman, Rawson, & Pyc, 2012), as well as the implementation of effective strategies by teachers in both K-12 and post-secondary settings (Dunlosky et al., 2013). For both students and teachers, a frequently recommended strategy that has been shown to improve learning is retrieval practice, or the use of practice tests and quizzes (e.g., Roediger, Putnam, & Smith, 2011). For programs of retrieval practice, whether implemented by the student at home or the teacher in the classroom, a potential criticism is that additional practice tests and quizzes will increase test anxiety (e.g., Steele,

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2011). As Dunlosky et al. (2013) surmised, “[W]e suspect that most students would prefer to take as few tests as possible” (p. 29). Is it the case that retrieval practice increases test anxiety, or does the improvement in learning from retrieval practice actually decrease test anxiety?

To investigate this issue, we administered a survey with more than 1400 public middle school and high school students (ages 11–18) across a variety of content areas (History, English, Science, Spanish, and Mathematics). A primary motivation for our survey was to examine students’ reactions to retrieval practice as a learning strategy, as all students who completed our survey also participated in yearlong classroom-based retrieval practice programs in which retrieving or calling information to mind improved long-term learning (Agarwal, Bain, & Chamberlain, 2012; McDermott, Agarwal, D’Antonio, Roediger, & McDaniel, 2014; McDaniel, Agarwal, Huelser, McDermott, & Roediger, 2011; McDaniel, Thomas, Agarwal, McDermott, & Roediger, 2013; Roediger, Agarwal, McDaniel, & McDermott, 2011; Roediger, Putnam, et al., 2011).

For the surveyed students, all of whom participated in classroom-based retrieval practice, the practice tests and quizzes were (1) typically administered via “clickers” or clicker response systems (although paper-and-pencil quizzes were used occasionally), and (2) typically involved low- or no-stakes (meaning the tests and quizzes did not count toward students’ grades). Retrieval practice was frequent, occurring at least once a week, and it almost always involved immediate feedback via the clicker response system. Across the different age groups, content areas, schools, and academic years in which the survey was conducted, the retrieval practice varied by type of question (e.g., multiple-choice, short answer, essay, fill-in-the-blank) and difficulty of question (e.g., key term definition, application, case-based). Other than the implementation of frequent quizzing, all classroom curricula, practices, exams, procedures, and lectures by the teacher remained unchanged.

A second motivation for our survey was to examine students’ study habits – to the best of our knowledge, the first survey of study habits for this pre-college age group. If middle school and high school students use ineffective study strategies, study strategy training programs may need to be implemented during elementary school, rather than during college when students’ use of ineffective study strategies has persisted for years.

2. Method

2.1. Participants

One thousand five hundred seventy-four students from a Mid-western suburban public school district were invited to complete our survey. Parents were informed of the study and assent from each student was obtained in accordance with Institutional Review Board guidelines. One hundred five students did not complete the survey, and sixty-one students completed the survey but declined to have their data included in analyses. Thus, we report data from 1408 students (1306 middle school students, 102 high school students, with ages ranging from 11 to 18 years, $M_{\text{age}} = 12.98$ years, 48% male). Participation in the survey was voluntary, thus not all students completed every question (tables report the precise number of student respondents for each survey question).

Students participated in various retrieval practice experiments from 2006 to 2013, and they completed the survey at the end of each academic year (i.e., June). Because we were not permitted to track students longitudinally, it is likely that students completed the survey more than once across the seven-year timespan (but always with at least one year between surveys). Typically, students

received retrieval practice in only one of the six classes they took, so many of our questions asked them to compare their experience in that class relative to other classes.

2.2. Materials

Our survey (see Appendix) included questions about the following: age, gender, time spent studying outside of class, time spent studying in this class, test anxiety, experience with retrieval practice via clickers (personal response systems), and strategies typically used while studying. The precise wording of questions varied slightly in accordance with content area (e.g., “What strategies do you use when you study outside of class for Science?” versus “What strategies do you use when you study outside of class for History?”), but overall the questions and the order of questions remained the same for each survey and for each classroom. For most questions, students were asked to select from a range of responses, and a few questions included space for free responses from students.

2.3. Procedure

Students were asked to complete the paper-and-pencil survey at the end of each academic year. Students were instructed that the survey was optional, that all responses were anonymous, and that responses would not affect their grades. Students were also instructed to read silently at their desk until all students completed the survey. The teacher or research assistant answered any questions students asked about the survey, passed out the survey, and students handed back their survey upon completion. Completion of the survey was self-paced and typically required 5–10 min of class time.

3. Results

3.1. Test anxiety

We asked students whether clicker quizzes (i.e., retrieval practice) made them more or less nervous for unit tests and exams (item 7 on the survey). Remarkably, 72% of students reported that retrieval practice made them *less* nervous for tests and exams, 22% said they experienced about the same level of nervousness, and only 6% of students said clickers made them more nervous. This pattern was consistent across content areas, gender, and students receiving special services (see Table 1). This finding suggests that experiencing retrieval practice makes students less anxious regarding upcoming tests and exams for classes in which retrieval practice was implemented.

Next, we asked students whether they experienced more, less, or about the same level of test anxiety for the class with retrieval practice compared to other classes in which they did not have retrieval practice (item 6 on the survey; see Appendix). Across all students, only 19% of students reported experiencing more anxiety, while 81% of students said they experienced about the same level of test anxiety or less in the class with retrieval practice compared to their other classes (33% reported less nervousness). Specifically, as displayed in Table 2, the *majority* of students in History and Spanish reported being less anxious compared to other classes (54% and 67%, respectively). In these two classes, fewer than 10% of students reported greater test anxiety compared to their other classes. In addition, almost half of all male students (40%) reported that retrieval practice reduced their test anxiety, while fewer female students (26%) reported decreased test anxiety.

Table 1

Percent of students who reported that retrieval practice specifically made them more nervous, less nervous, or about the same level of nervousness before unit tests on survey question 7 (“Did clicker quizzes make you more or less nervous for unit tests?”).

	More	Less	About the same
All students (1404)	6%	72%	22%
Middle school (1302)	6%	73%	21%
High school (102)	6%	63%	31%
Content area			
Science (814)	6%	70%	24%
Math (123)	9%	58%	33%
History (176)	8%	80%	12%
English (124)	5%	84%	11%
Spanish (167)	4%	76%	20%
Gender			
Female (726)	6%	72%	22%
Male (682)	6%	72%	22%
Additional services			
None (1156)	5%	73%	22%
Gifted programs (107)	3%	81%	16%
Special education (81)	15%	54%	31%
Tutoring (60)	10%	67%	24%

Note. Numbers in parentheses represent the number of student respondents. Percentages may not sum to 100% due to rounding.

3.2. Retrieval practice preferences

A primary motivation of this study was to ascertain students’ reactions to classroom-based retrieval practice programs (e.g., Agarwal et al., 2012; McDaniel et al., 2011, 2013; McDermott et al., 2014; Roediger, Agarwal, et al., 2011; Roediger, Putnam, et al., 2011), where anecdotal and observational evidence suggested that students enjoyed participating in retrieval practice. From item 10 on our survey, 92% reported that clickers helped them learn and only 8% reported that clickers did not help them learn (see Table 3).

Next, in question 11, we asked the students who responded “yes” to the previous question why clickers helped them learn, and they could select a number of options provided. As displayed in Table 4, on average 70% of students reported that clicker quizzes helped them to prepare them for an upcoming test, 69% reported that clicker quizzes helped by reviewing/summarizing past class topics, 68% felt that quizzes helped them distinguish between what they knew and did not know (increased metacognitive awareness),

Table 2

Percent of students who reported more, less, or about the same test anxiety for the class with retrieval practice, compared to other classes, on survey question 6 (“How much anxiety [nervousness or stress] did you experience before a unit test in this class in comparison to other classes?”).

	More	Less	About the same
All students (1304)			
Middle school (1304)	19%	33%	48%
High school (0)		No responses	
Content area			
Science (763)	21%	25%	54%
Math (124)	26%	23%	52%
History (126)	9%	54%	37%
English (124)	30%	23%	47%
Spanish (167)	5%	67%	28%
Gender			
Female (676)	23%	26%	51%
Male (628)	15%	40%	45%
Additional services			
None (1066)	20%	33%	47%
Gifted programs (107)	7%	40%	53%
Special education (72)	17%	31%	53%
Tutoring (59)	32%	19%	49%

Note. Numbers in parentheses represent the number of student respondents. High school students were not asked this question. Percentages may not sum to 100% due to rounding.

Table 3

Percent of students who reported that retrieval practice helped them learn on survey question 10 (“Did clickers help you learn?”).

	Yes	No
All students (1227)	92%	8%
Middle school (1132)	92%	8%
High school (95)	87%	13%
Content area		
Science (657)	88%	12%
Math (116)	94%	6%
History (174)	96%	4%
English (121)	96%	4%
Spanish (159)	94%	6%
Gender		
Female (644)	90%	10%
Male (583)	93%	7%
Additional services		
None (1020)	92%	8%
Gifted programs (94)	96%	4%
Special education (65)	82%	18%
Tutoring (48)	85%	15%

Note. Numbers in parentheses represent the number of student respondents.

Table 4

Percent of students (from those who responded yes to survey question 10, see Table 3 who reported a specific benefit from retrieval practice on survey question 11 (“If clickers helped you learn, please select the reasons why.”).

	Test preparation	Review/ summarize	Meta cognition	Provided feedback
All students (1123)	70%	69%	68%	67%
Middle school (1039)	73%	67%	69%	67%
High school (83)	34%	82%	54%	66%
Content area				
Science (580)	71%	69%	64%	67%
Math (109)	73%	65%	61%	52%
History (167)	58%	72%	80%	70%
English (116)	73%	72%	74%	69%
Spanish (150)	79%	64%	78%	73%
Gender				
Female (582)	73%	68%	72%	68%
Male (540)	68%	69%	64%	66%
Additional services				
None (938)	72%	69%	71%	67%
Gifted programs (90)	73%	79%	67%	82%
Special education (53)	48%	55%	48%	46%
Tutoring (41)	62%	52%	56%	58%

Percent of students who reported a specific benefit from retrieval practice on survey question 11 (“If clickers helped you learn, please select the reasons why.”)

	Reduced anxiety	Helped me focus	Fun
All students	53%	40%	23%
Middle school	54%	39%	22%
High school	34%	61%	35%
Content area			
Science	50%	36%	14%
Math	51%	48%	35%
History	54%	57%	51%
English	55%	35%	39%
Spanish	61%	36%	8%
Gender			
Female	53%	39%	19%
Male	52%	41%	27%
Additional services			
None	54%	41%	22%
Gifted programs	60%	32%	21%
Special education	26%	36%	23%
Tutoring	50%	48%	34%

Note. Numbers in parentheses represent the number of student respondents. Percentages may not sum to 100% as students could select more than one option.

Table 5

Percent of students who reported a specific dislike about retrieval practice on survey question 12 (“Was there anything about the clicker quizzes you did not like, even if they helped you learn?”).

	Boring	Nothing I didn't like	Went too quickly	Made me nervous
All students (883)	47%	24%	14%	8%
Middle school (788)	48%	25%	15%	6%
High school (95)	37%	16%	6%	20%
Content area				
Science (544)	55%	20%	11%	8%
Math (124)	19%	44%	18%	6%
History (49)	37%	12%	6%	10%
English (0)			No responses	
Spanish (166)	43%	27%	25%	8%
Gender				
Female (473)	49%	22%	16%	12%
Male (410)	44%	27%	12%	3%
Additional services				
None (722)	48%	23%	15%	8%
Gifted programs (65)	42%	35%	6%	2%
Special education (46)	33%	26%	15%	13%
Tutoring (50)	44%	24%	14%	2%

Note. Numbers in parentheses represent the number of student respondents. English students were not asked this question. Percentages may not sum to 100% as students could select more than one option.

67% of students felt quizzes helped them learn because feedback was presented, 53% reported that the quizzes reduced test anxiety, 40% felt that quizzes helped them pay attention, and 23% felt that clickers helped them learn because it was fun.

Interestingly, regarding reasons why clicker quizzes and retrieval practice may have benefitted learning, a vast majority of high school students (82%) selected course review/summary, whereas a majority (73%) of middle school students selected test preparation. More middle school students felt that retrieval practice reduced anxiety compared to high school students (54% and 34%, respectively), whereas more high school students felt that retrieval practice increased focus and attention compared to middle school students (61% and 39%, respectively). Male and female students did not differ in terms of their preferences, while students receiving additional services demonstrated a few differences. For instance, 79% of gifted students reported that retrieval practice was helpful because of class review, whereas 62% of students receiving one-on-one tutoring by teachers reported that retrieval practice was helpful because of test preparation. In addition, 60% of gifted students reported that retrieval practice reduced anxiety and 82% of gifted students reported that retrieval practice was helpful by providing feedback.

Finally, we asked the students if there was anything they did not like about clicker quizzes, even if retrieval practice helped them learn (item 12 on the survey). As displayed in Table 5, 47% of all students reported that retrieval practice was boring (particularly those in Science), 24% selected “nothing I didn’t like” about retrieval practice, 14% felt that the clicker quizzes went too quickly, and 8% of students on average reported that clicker quizzes made them nervous.

3.3. Study strategy preferences

Next, we consider results from the part of the survey in which students were provided a list of potential study strategies and asked to indicate which strategies they use, with the option to select more than one strategy (item 8 on the survey). As displayed in Table 6, 45% of all students reported that they reviewed course materials while studying (the most commonly reported strategy), 42% of students reported that they repeated facts or key terms over and over, 35% reported being tested by someone else, 31% checked off

Table 6

Percent of students who reported using a particular study strategy on survey question 8 (“What strategies do you use when you study outside of class?”).

	Review materials	Repeat facts	Tested by someone else	Think of clicker quizzes
All students (1396)	45%	42%	35%	31%
Middle school (1294)	44%	41%	36%	30%
High school (102)	57%	55%	25%	40%
Content area				
Science (804)	46%	44%	36%	31%
Math (124)	55%	39%	44%	24%
History (178)	50%	48%	37%	42%
English (124)	54%	48%	42%	31%
Spanish (166)	17%	25%	16%	23%
Gender				
Female (721)	50%	47%	39%	35%
Male (675)	39%	37%	31%	27%
Additional services				
None (1150)	45%	43%	36%	31%
Gifted programs (106)	37%	33%	26%	29%
Special education (80)	51%	44%	33%	25%
Tutoring (60)	47%	40%	40%	38%

	Mnemonics	Self-test	Flashcards	Other
All students	31%	30%	20%	7%
Middle school	31%	30%	20%	7%
High school	33%	34%	21%	10%
Content area				
Science	30%	31%	21%	7%
Math	27%	31%	27%	11%
History	43%	26%	26%	11%
English	54%	39%	19%	6%
Spanish	7%	23%	5%	4%
Gender				
Female	38%	31%	24%	8%
Male	24%	30%	16%	7%
Additional services				
None	31%	32%	19%	7%
Gifted programs	28%	21%	8%	7%
Special education	35%	16%	40%	9%
Tutoring	32%	32%	22%	10%

Note. Numbers in parentheses represent the number of student respondents. Percentages may not sum to 100% as students could select more than one option.

that they thought back to clicker quizzes/retrieval practice, 31% reported using mnemonics, 30% self-tested, 20% reported using flashcards, and 7% reported other strategies. Note that students who completed our survey also participated in classroom-based retrieval practice programs, and thus this feature of the study may have inflated students’ reports of using testing as a study strategy. In particular, an increased proportion of students in English may have reported that they self-test, probably because material in this class was well suited for testing (e.g., lists of various vocabulary and grammatical terms, including prepositions, participles, etc.).

In terms of noteworthy comparisons between student populations, the data in Table 6 suggest that a third of middle school students are tested by someone else (36%), and this percentage decreased to 25% of high school students being tested by someone else. Conversely, about 40% of middle school students reported reviewing materials and repeating facts over and over, and this strategy use increased by high school, when more than 50% of students reported that they review materials and repeat facts while studying. Use of simple strategies like reviewing materials and repeating facts is also common for special education students, more so than for students in gifted or tutoring programs. Surprisingly, 40% of students in special education programs reported using flashcards, compared to only 8% of students in gifted programs (who more commonly reported reviewing materials). However, special education students received considerable instruction outside

Table 7

Percent of students who reported studying alone or with another person on survey question 9 (“With whom do you normally study for a test?”).

	Alone	Parent or guardian	With a friend	Study group	Other
All students (1388)	40%	30%	20%	5%	4%
Middle school (1293)	38%	32%	20%	5%	3%
High school (95)	66%	15%	26%	4%	7%
Content area					
Science (799)	42%	32%	21%	5%	3%
Math (124)	35%	48%	19%	3%	6%
History (175)	44%	32%	17%	4%	6%
English (124)	43%	35%	24%	10%	5%
Spanish (166)	28%	6%	15%	3%	2%
Gender					
Female (720)	43%	32%	26%	5%	4%
Male (668)	37%	29%	14%	5%	3%
Additional services					
None (1142)	40%	31%	20%	4%	4%
Gifted programs (106)	40%	19%	13%	2%	0%
Special education (80)	38%	30%	16%	16%	11%
Tutoring (60)	38%	30%	32%	15%	3%

Note. Numbers in parentheses represent the number of student respondents. Percentages may not sum to 100% as students could select more than one option.

of class and thus they may have been reporting that their extra instruction included a considerable amount of self-testing.

Across content areas, the most common study strategy in Science, Math, and History was to review materials. In English, review and mnemonics were most common, whereas in Spanish, the repetition of facts was most common (see Table 6). The strategy of being tested by someone else was reported most often for students in Math, whereas thinking of clicker quizzes/retrieval practice was most commonly reported in History. The use of flashcards was also commonly reported in Math, and self-testing was most common in English.

To provide additional information about students’ study strategies, we asked students whether they typically study alone or with someone else (item 9 on the survey). As displayed in Table 7, 40% of students reported that they studied alone, 30% with a parent/guardian, 20% with a friend, 5% with a group, and 4% reported using other studying arrangements. Studying alone was particularly common for high school students (66%) and for History content (44%), whereas studying with a parent/guardian was more common for middle school students (32%) and for Math content (48%). Students who received tutoring services or those who were in English classes reported studying with a friend more often than other students (32% and 24%, respectively). Students who received special education services most often reported studying with a study group (16%).

3.4. Time spent studying

When asked to provide a free response about study time for the class in which they were completing the survey (item 3), students reported spending an average of 19 min/week studying outside of class when there were no tests that week, compared to 43 min/week studying outside of class when there was an upcoming test (see Table 8). The average amount of time spent studying did not differ much between middle school and high school students (a difference of 4–5 min). If students had an upcoming test in a course, they reported spending the most amount of time studying for it if it was in Math (55 min) and the least amount of time studying if it was in English (32 min). If students did not have an upcoming test, they reported spending the most amount of time studying History (27 min) and the least amount of time spent studying English (11 min).

Table 8

Students’ self-reported time spent studying per week on survey questions 3 and 4 (“How much did you study outside of class on a weekly basis when there was not a test that week?” and “How much did you study outside of class right before a test?”).

	Weekly study time, no upcoming test (min)	Weekly study time, upcoming test (min)
All students	18.90 (1386)	42.78 (1222)
Middle school	18.52 (1287)	42.65 (1123)
High school	23.74 (99)	44.29 (99)
Content area		
Science	18.77 (805)	42.27 (805)
Math	25.09 (118)	55.14 (118)
History	27.20 (175)	44.48 (175)
English	11.11 (124)	31.97 (124)
Spanish	12.09 (164)	No responses
Gender		
Female	17.33 (716)	43.86 (632)
Male	20.57 (670)	41.63 (590)
Additional services		
None	17.40 (1145)	41.15 (994)
Gifted programs	4.34 (106)	14.98 (95)
Special education	50.62 (78)	94.75 (76)
Tutoring	32.53 (57)	48.32 (57)

Note. Numbers in parentheses represent the number of student respondents.

Regarding student populations, self-reported study time varied only 2–3 min between males and females, whereas estimates of study time varied widely across students receiving additional educational services. Compared to other students, special education students reported spending the most amount of time studying (50 min without a test, 95 min with a test). Students in gifted programs reported spending the least amount of time studying (4 min without a test, 15 min with a test), with intermediate amounts of studying for students who did not receive additional services and students who received tutoring services. Interestingly, special education students increased their study time by approximately 45 min with an upcoming test, whereas gifted students only increase their study time by 10 min with an upcoming test. Based on our informal observations, this study time difference between gifted and special education students is likely attributable to the fact that gifted students could study very little and achieve high grades at the participating schools, while students receiving special education services were held to the same standard of rigor and took the

Table 9

Percent of students who reported studying more, less, or about the same for classes with retrieval practice, compared to other classes without retrieval practice on survey question 5 (“How much did you study outside of class in comparison to other classes?”).

	More	Less	About the same
All students (1304)	12%	26%	62%
Middle school (1304)	12%	26%	62%
High school (0)	No responses		
Content area			
Science (764)	15%	16%	69%
Math (124)	11%	42%	47%
History (125)	11%	16%	73%
English (124)	9%	24%	67%
Spanish (167)	1%	70%	29%
Gender			
Female (677)	14%	26%	60%
Male (627)	9%	27%	64%
Additional services			
None (1065)	12%	28%	61%
Gifted programs (106)	8%	25%	67%
Special education (73)	16%	14%	70%
Tutoring (60)	15%	22%	63%

Note. Numbers in parentheses represent the number of student respondents. High school students were not asked this question. Percentages may not sum to 100% due to rounding.

same tests as gifted students. Accordingly, students receiving special education services were encouraged to study for longer periods of time and were afforded such study time both during and after school.

In addition, students (middle school only) were asked whether they studied more, less, or about the same for the class in question versus other classes, as a potential indicator of whether retrieval practice (implemented in the class in question) increased or decreased students' study time (item 5). The majority of students (62%) reported that they spent about the same amount of time studying for the class with retrieval practice compared to other classes. Notably, 26% of students said they studied less, and only 12% of students said they studied more, in classes with retrieval practice. This pattern was consistent across content areas, gender, and students receiving special services (see Table 9), suggesting that students did *not* study more for classes in which retrieval practice was implemented. The only exception was in Spanish, where 70% of students reported studying less for Spanish than for their other classes.

4. Discussion

A primary motivation for our study was to examine the relationship between a classroom-based program of retrieval practice and students' self-reported level of test anxiety. Our main finding is that the use of clicker response systems reduced self-reported test anxiety. A large majority of students (72%) reported feeling less anxious about taking unit tests (that counted for a grade) when they had taken clicker quizzes. Most students (81%) reported either the same amount of test anxiety or a lesser amount in their classes in which they received clicker quizzes than in their other classes. We hypothesize that students became familiar with taking quizzes, knew the course material better, and hence were less anxious when facing the unit test on which they would receive a grade. Of course, the fact remains that 19% of students reported experiencing greater test anxiety from the quizzing procedure. Future research should examine possible interactions between student characteristics and the inducement of test anxiety from quizzing, but it seems that for the great majority of students daily quizzing produces either no change in test anxiety or a lessening of anxiety.

A second motivation for our study was to examine the strategies that middle school and high school students use while studying. Our main findings were that students report reviewing course materials (textbooks, notes, etc.) as their preferred strategy (45%),

with the next most common strategy being repeating facts or key terms over and over (42%). These data are similar to those obtained in surveys of college students (e.g., Karpicke et al., 2009).

One limitation of the current study is that students were participating in a classroom study on quizzing/retrieval practice during the academic year prior to completing the survey. Their participation might have increased their reported use of retrieval practice. Future surveys might be given to students from a variety of middle and high schools in which no experimental research is ongoing to determine if our findings generalize to students not engaged in frequent quizzing in the classroom (unless it is part of some teachers' normal teaching practice). Other work might encourage more open-ended responses from students regarding their study habits; such an approach would rely less on students' interpretations of the researcher's wording choices and would permit students to describe in their own words how they study. It may be that students in our sample informally or covertly test themselves on a routine basis, but that the survey choices did not reveal these practices.

4.1. Practical applications

Based on our survey data from more than 1400 middle school and high school students, we recommend two practical applications of our findings:

1. Retrieval practice, or the use of low- or no-stakes quizzes in the classroom, can be implemented school-wide *without* increasing students' self-reported test anxiety. In fact, frequent quizzing seems to alleviate test anxiety.
2. Students as young as middle school and high school aged should be encouraged to use retrieval practice as a study strategy and veer away from less effective study strategies commonly used by students throughout their lifespan, such as material review (re-reading) and fact repetition.

The sooner that students adopt retrieval practice as part of their study strategy repertoire, and teachers do the same as part of their teaching repertoire, the sooner they can reap the rewards of more efficient and more effective long-term learning.

Conflict of interest statement

The authors declare that they have no conflict of interest.

Appendix. Example survey

Hour: _____ Clicker #: _____ Initials: _____ Date: _____

1. How old are you? _____

2. Are you male or female? _____

3. How much did you study outside of class for Science on a weekly basis when there was not a test that week?

_____ Hours _____ Minutes

4. How much did you study outside of class for Science right before a test?

_____ Hours _____ Minutes

For the following questions,
CIRCLE ONE ANSWER.

5. How much did you study outside of class for Science in comparison to other classes?

More About the same Less

6. How much anxiety (nervousness or stress) did you experience before a unit test in Science in comparison to other classes?

More About the same Less

7. Did clicker quizzes make you more or less nervous for unit tests?

More About the same Less

8. What strategies do you use when you study outside of class for Science?

Circle all answers that apply.

- a. Mnemonics (rhymes, acronyms, memory tricks to help you remember things)
- b. Repeating key facts/terms over and over
- c. Using flashcards
- d. I test myself (not using flashcards)
- e. Someone else tests me (not using flashcards)
- f. Thinking of clicker quizzes and remembering the correct answers
- g. Reviewing materials (guides, packets, notes, textbook)
- h. Other (please write what other strategies you use):

9. With whom do you normally study for a Science test?
- Alone
 - With one other friend
 - With a study group
 - With a parent/guardian
 - Other: _____
10. Did clickers help you learn Science?
- | | |
|-----|----|
| Yes | No |
|-----|----|
11. If clickers helped you learn Science, please select the reasons why:
12. Was there anything about the clicker quizzes you did not like, even if they helped you learn?

Circle all answers that apply.

- They went too quickly
- They made me nervous
- They were boring
- Nothing I didn't like
- Other (please write why): _____

Circle all answers that apply.

- They review/summarize what we went over in class
- They help me to prepare for what is on the unit tests
- They are fun
- They make me less nervous/anxious about the upcoming unit tests
- They keep me focused on the material/helped me pay attention
- They show me the correct answer
- They help me figure out what I know and what I don't know
- I don't know why I think clickers help
- Other (please write why): _____

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